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The transmission of 625-line television signals in Bands I and III

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THE TRANSMISSION OF 625-LINE TELEVISION SIGNALS IN BANDS I AND III

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(1965/43)

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THE TRANSMISSION OF 625-LINE TELEVISION SIGNALS IN BANDS I AND III

SUMMARY

The 625-line transmission standard used in the United Kingdom employs r.f. channels 8 Mc/s wide, which could not be accommodated in the v.h.f. Bands I and III without reducing the number of channels available. Two proposals have been made for modifying the standard to enable the existing 5 Mc/s channels to be used. In the first proposal, the video-frequency bandwidth is reduced to 3 Mc/s, whilst in the second proposal a video bandwidth of approximately 4·5 Mc/s is made available by transmitting the sound signal as a suitably-modulated pulse-train incorporated in the video-frequency signal instead of as the modulation of a radio-frequency carrier.

A series of subjective tests has been carried out to investigate both proposals and conclusions have been drawn as to their suitability. An outline specification is given for the radiated spectrum in the case of the second proposal.

1. INTRODUCTION

The 625-line transmission standard used in the United Kingdom (Standard I) employs r.f. channels 8 Mc/s wide, which could not be accommodated in the v.h.f. Bands I and III without reducing the number of channels available. This report describes an investigation into two proposals that have been made for modifying the standard so that 625-line transmissions can be accommodated in the existing v.h.f. channels, which are 5 Mc/s wide.

In the first proposal, the 625-line television signal would be transmitted with the video-frequency bandwidth reduced to 3 Mc/s so that the present v.h.f. vision and sound carrier frequencies could be used. Receivers could therefore be similar to those used at present for 405-line reception, so far as r.f. and i.f. responses are concerned, and it would be possible to use positive modulation of the vision carrier; thus little change in receiver design would be involved. The sound transmission would utilise a separate amplitude-modulated sound carrier so that, once again, very few modifications would be required in either the transmitter or the receiver. In this report, this proposal will be referred to as 'Narrow-Band 625'. A variation of this proposal would use negative modulation of the vision carrier and frequency-modulation of the sound carrier. The resulting standard would thus be similar in many respects to the existing 625-line standard used in the United Kingdom and would be more convenient for reception by single-standard, all-band receivers. As will be seen in Section 4.1, however, the performance to be expected in such a case is not likely to differ significantly from that to be expected from the 'Narrow-Band 625' proposal.

In the second proposal, the sound signal would be incorporated in the video-frequency signal as a suitably-modulated train of pulses at line-scan frequency. This method, which will be referred to as 'Pulse-Sound 625', would obviate the need for a separate radio-frequency sound carrier and would thus permit the whole of the available channel-bandwidth to be occupied by the composite sound and vision signal.

2. TRANSMISSION OF 625-LINE SIGNALS IN A 5 Mc/s CHANNEL

The 'Narrow-Band 625' proposal could be implemented literally overnight once the viewers had equipped themselves with suitable receivers; it would be necessary for each receiver to be equipped with a separate 405/625 switch controlling the scanning circuits independently of the receiver's band-selecting switch.* It should be noted, however, that colour signals could only be transmitted if the colour-sub-carrier frequency used were much lower than the proposed value of approximately 4·43 Mc/s.

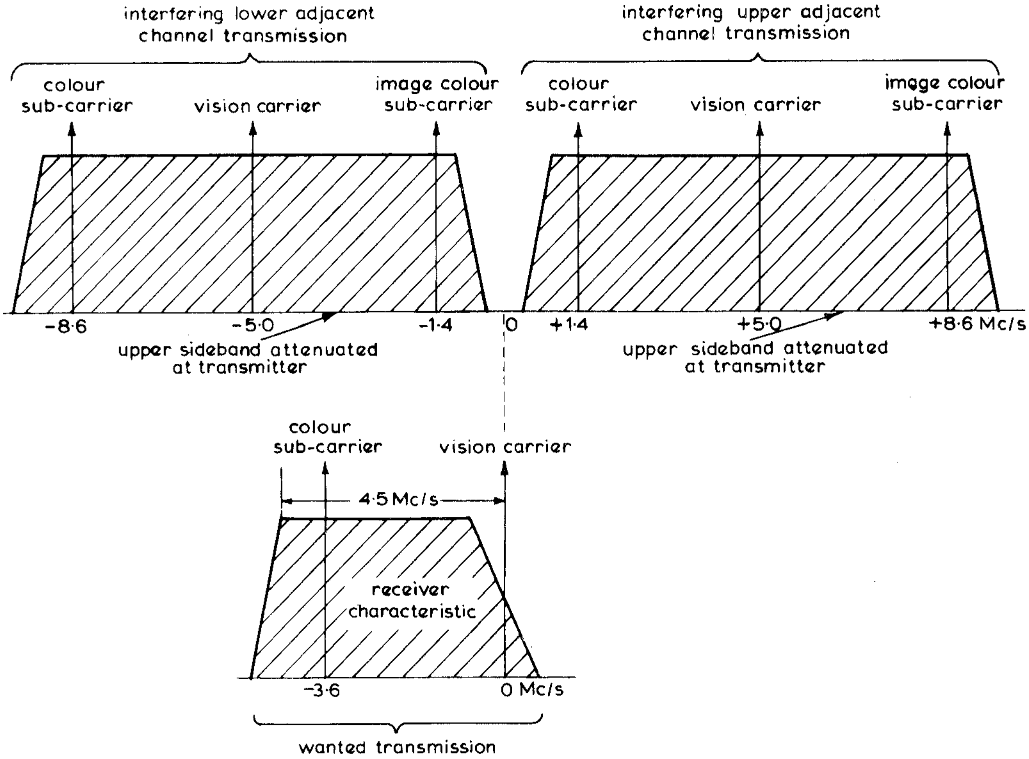

Fig. 1 - Possible use of 5 Mc/s channels for 625-line signals and pulse-sound

* In the present generation of British television receivers, a change from u.h.f. to v.h.f. is accompanied by a simultaneous change from 625- to 405-line scanning on the operation of a single control. It is possible, however, that most designs could be readily modified to separate the functions of channel selection and scanning standard.

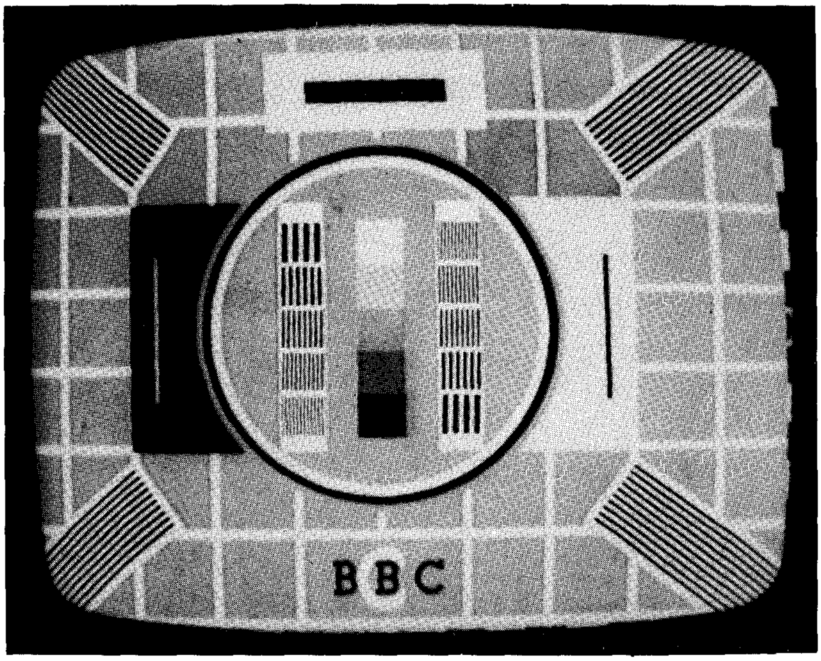

Fig. 2 - (a) Test Card 'C' displayed by receiver in 'normal 625' condition

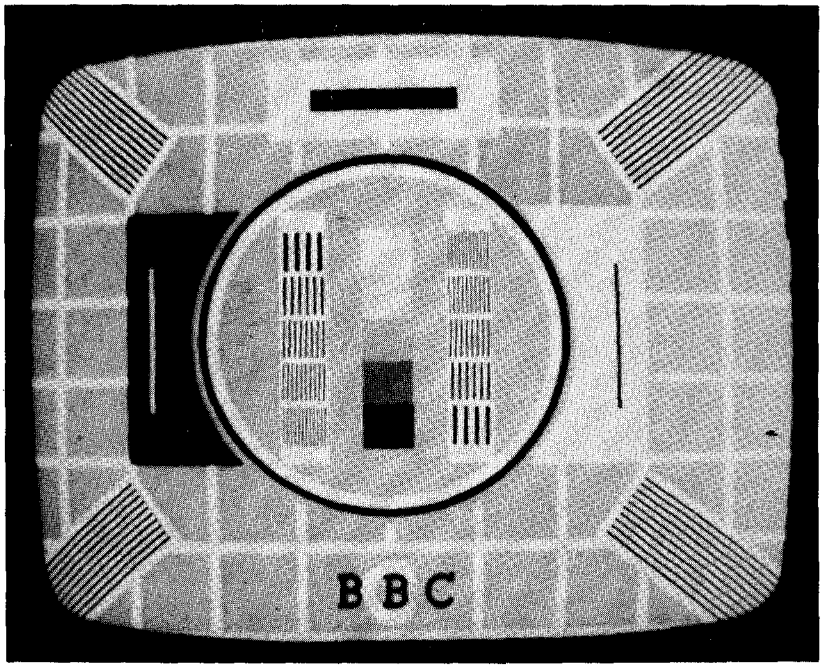

Fig. 2 - (b) Test Card 'C' displayed by receiver in 'normal 405' condition

The implementation of the 'Pulse-Sound 625' proposal would be more complicated and a discussion of the problems involved is beyond the scope of this report. However, if colour transmissions were made using the 'Pulse-Sound 625' system, a colour-subcarrier frequency below 4·43 Mc/s would again be necessary. The video-frequency bandwidth which could be obtained using 'Pulse-Sound 625' is discussed in the Appendix and it is concluded that the transmitted spectrum would probably be as illustrated in Fig. 1, the parameters being:

Channel bandwidth : 5 Mc/s

Bandwidth of vestigial sideband : 1 Mc/s.

Nominal video bandwidth : 4·5 Mc/s.

Colour subcarrier (when used) : 3·6 Mc/s (approximately).

Vision modulation : Negative.

3. SUBJECTIVE TESTS

The implementation of either of the two proposals, and in particular the 'Narrow-Band 625' proposal, would inevitably result in an impairment of the quality of the pictures received by the viewer. It was decided, therefore, to carry out a series of subjective tests in order to compare the two proposed standards with the normal 625- and 405-line standards. It was also decided that the most realistic results would be obtained by using a normal domestic receiver, since many of the imperfections occurring in practice would then be present. On the other hand, it was felt that in order to carry out a realistic appraisal, the picture quality should be the best that could be expected from a domestic receiver of normal price. A current type of receiver was therefore selected and carefully re-aligned. Figs. 2(*a*) and 2(*b*) show photographs of Test Card 'C' displayed by the receiver after re-alignment and it is considered that the picture quality obtained was representative of the best standard of domestic-receiver performance that could reasonably be expected. Fig. 3(*a*) shows the response/frequency characteristic of the receiver in the condition used for reception of normal 405-line television signals, whilst Fig. 3(*b*) shows the response/frequency characteristic when switched to receive normal 625-line transmissions. To facilitate comparisons, the frequency scale of Fig. 3(*a*) has been reversed, the lower sideband being used for the tests as for normal v.h.f. reception. Investigation showed that the performances in both conditions were superior to those of most domestic receivers, but whilst the curve in Fig. 3(*a*) falls very close to the ideal, it will be seen that the response of the receiver shown in Fig. 3(*b*) falls somewhat short. The failure of the curve in Fig. 3(*b*) to meet the ideal characteristic was, however, regarded as realistic for two reasons. First, in a practical case, a good response-characteristic is more easily and cheaply achieved in the case of the narrower bandwidth. Second, with the advent of colour transmissions, the designers of monochrome receivers may produce a response/frequency characteristic that is substantially reduced at 4·43 Mc/s in order to minimise the effects of the colour subcarrier.

Fig. 3(*c*) shows the response/frequency characteristic of the receiver when simulating the reception of 625-line television signals employing pulse-sound. To

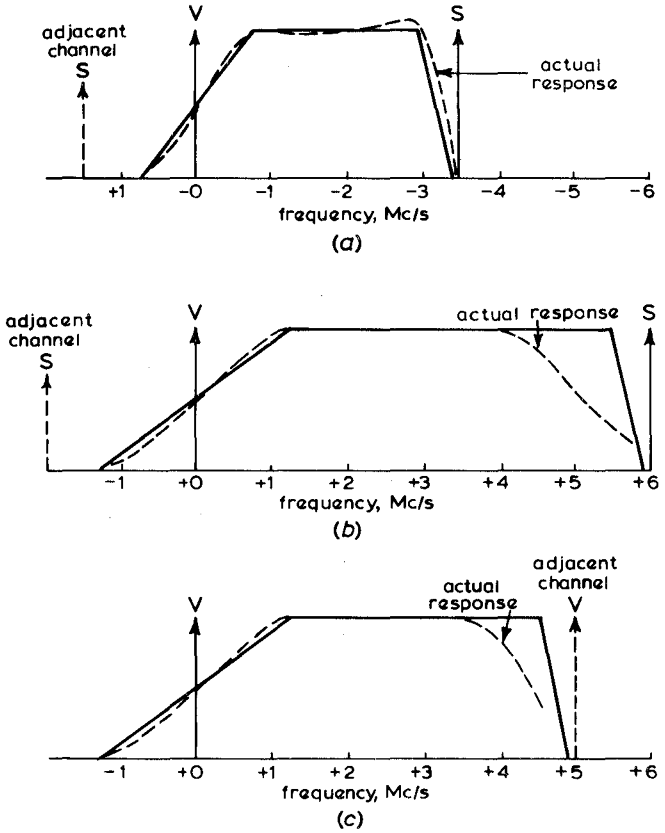

Fig. 3 - Ideal and actual receiver responses

(*a*) 'Normal 405' (5 Mc/s channel)
(*b*) 'Normal 625' (8 Mc/s channel)
(*c*) 'Pulse-Sound 625' (5 Mc/s channel)
V = vision carrier
S = sound carrier

simplify the instrumentation, this characteristic was obtained by using the response shown in Fig. 3(*b*), together with a simple video-frequency low-pass filter located in the video input to the transmitter.

The radio-frequency picture signals used for the subjective tests were derived using a high-quality variable-standards slide-scanner, together with v.h.f. and u.h.f. modulators giving positively and negatively modulated signals in Channels 5 and 32 respectively. The modulation standards were the same as those used for present BBC transmissions. The signal-to-noise ratio of the displayed picture was very high at all times and still pictures were used in order to enable the observers to carry out their comparisons unimpeded by variations in picture material.

3.1. Choice of Observers

It was decided to use twenty non-technical and ten technical staff as observers. The non-technical observers were selected from staff who were not experienced in the assessment of television pictures; the group consisted solely of adults, of which 25% were women. The technical staff were all engineers experienced in the assessment of television pictures; the results of their observations were thought to give some indication of the opinions of the most discriminating section of the public.

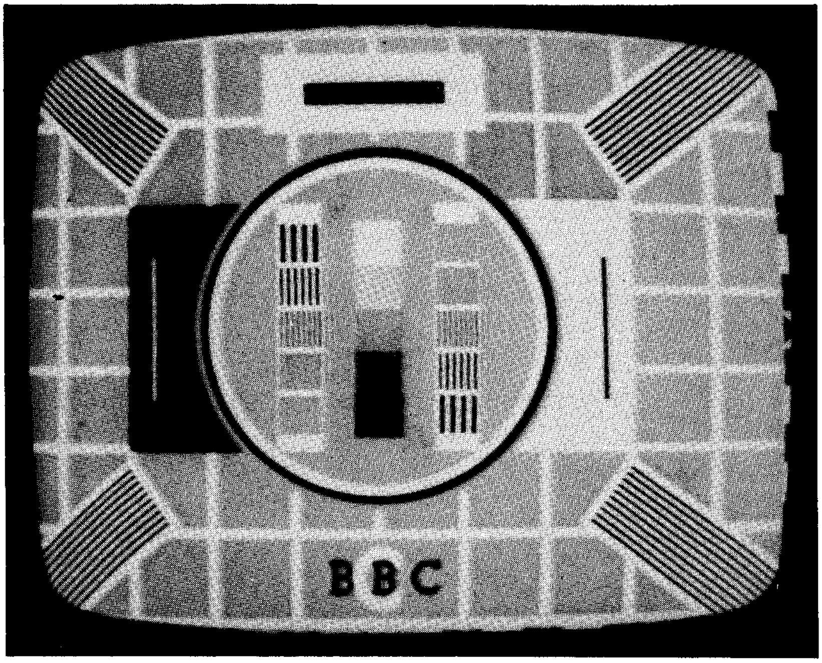

Fig. 4 - Test Card 'C' displayed by receiver in 'Narrow-Band 625' condition

3.2. Test Procedure

The tests involved four different conditions of reception and were carried out in two parts. In the first part, the 'Narrow-Band 625' condition was assessed and compared with 'normal 405' and 'normal 625' conditions of reception. In the second part of the test, the 'Pulse-Sound 625' condition was assessed and compared with 'normal 405' and 'normal 625' reception. Throughout the tests only a vision signal was generated and no sound signal was transmitted.

None of the observers was allowed to see a test card displayed on the receiver, nor to observe the settings of the receiver controls. This was thought necessary in order to avoid any possibility of observers identifying the various conditions under which the pictures were shown. The revealing nature of the test card display can be seen by comparing the photograph shown in Fig. 4, which was taken in the 'Narrow-Band 625' condition, with those shown in Figs. 2(*a*) and 2(*b*) for normal reception.

The viewers were not asked to base their assessment on any particular aspect of picture impairment but to make an overall judgement of picture quality; it is likely, therefore, that differences between the 405-line and 625-line pictures other than those concerned with bandwidth limitation affected the results. It was not considered practicable, however, to ask the observers to assess picture impairment with regard to only one feature of the picture. During an initial series of tests, each condition was allocated a code number, defining it to the observers, but it was later thought that the results might have been influenced because the viewers' assessments of a particular condition were conditioned by their previous assessments of the same

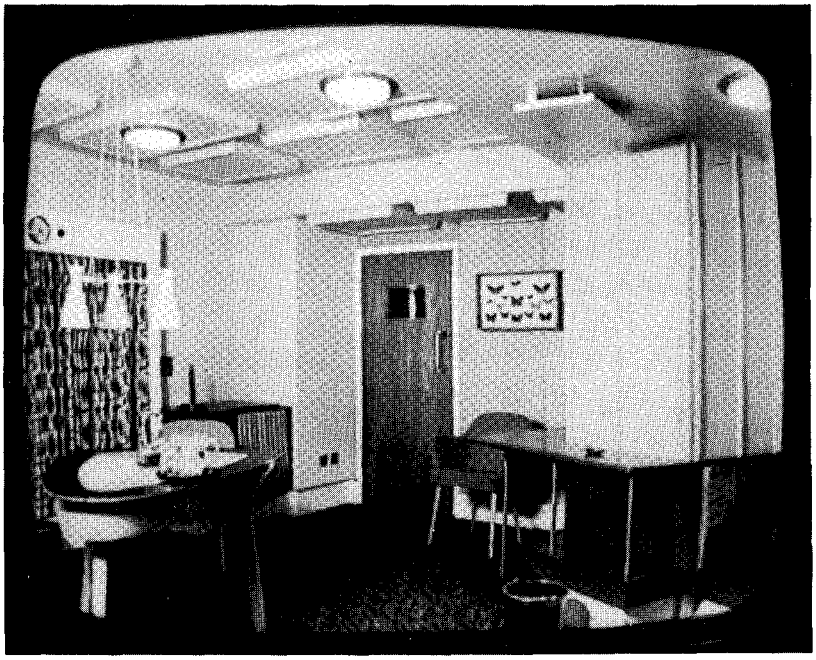

Fig. 5 - (a) Picture displayed by receiver in 'normal 625' condition

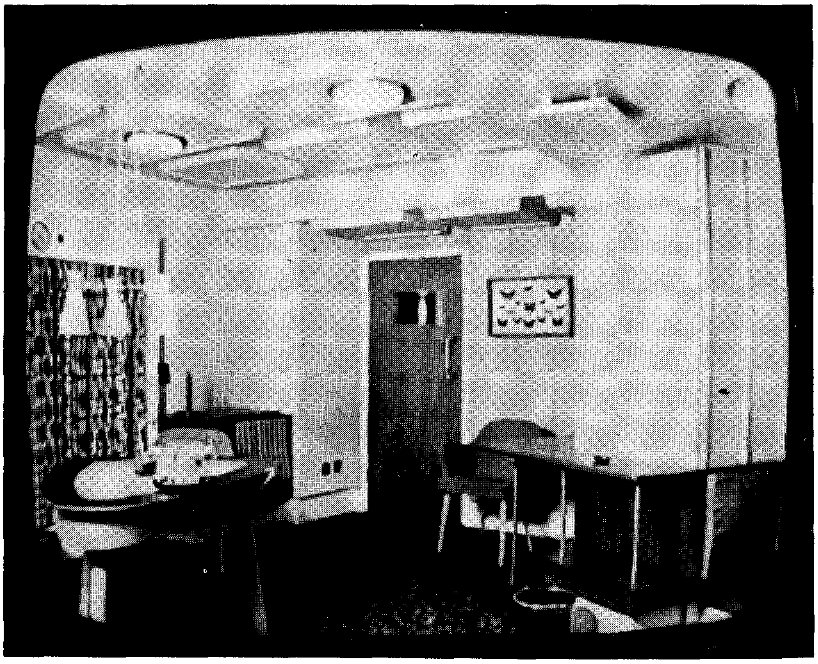

Fig. 5 - (b) Picture displayed by receiver in 'normal 405' condition

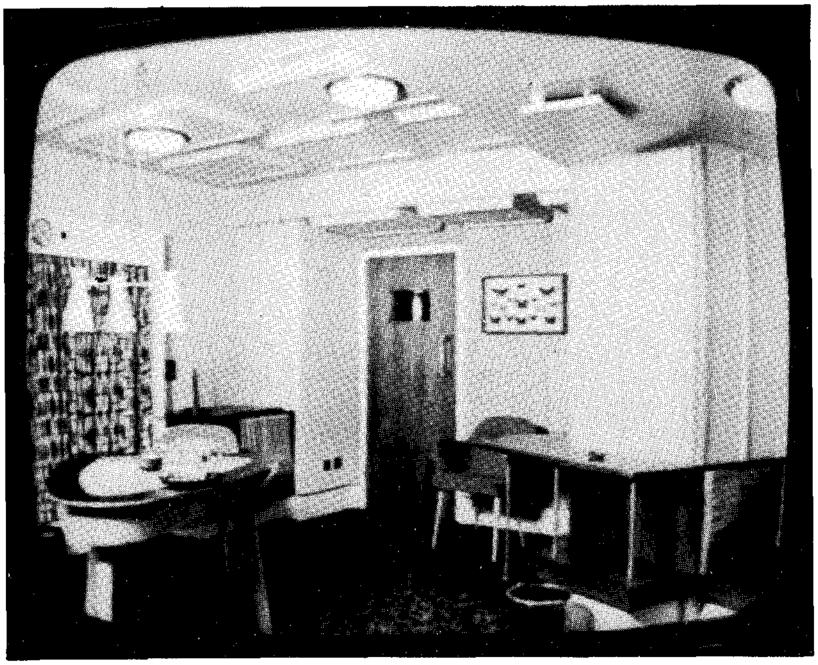

Fig. 5 - (c) Picture displayed by receiver in 'Narrow-Band 625' condition

condition. Further tests were carried out, therefore, in which the code numbers were not always associated with the same test condition, but it was found that the results obtained were substantially identical with those obtained previously. It was also thought possible that the type of coupling between the video detector and the cathode-ray tube of the receiver might have affected the results; it was found, however, that two series of tests, one with a receiver with only a.c. coupling and one with full d.c. coupling, gave similar results.

TABLE 1

PICTURE QUALITY SCALE	COMPARATIVE PICTURE QUALITY SCALE
ABSOLUTE GRADES (A)	COMPARATIVE GRADES (C)
1A : Excellent	-3C : Much worse
2A : Good	-2C : Worse
3A : Fairly good	-1C : Slightly worse
4A : Rather poor	0 : Same as
5A : Poor	+1C : Slightly better
6A : Very poor	+2C : Better
	+3C : Much better

Six slides were chosen as being typical of studio and outdoor scenes and Figs. 5(*a*), (*b*) and (*c*) show photographs of the displayed picture obtained under three of the four conditions using one of the selected slides. No photographs are shown for the 'Pulse-Sound 625' condition because the difference between this condition and 'normal 625' reception was insufficient to be detectable in photographic reproductions. Each slide was shown under each of the four conditions of reception and the observers were first asked to give an assessment of picture quality for each slide under each condition; they used the six-point subjective scale of absolute picture quality shown in Table 1. The observers were then asked to make comparisons in which each of the proposed systems was compared with 'normal 405' and 'normal 625', using the comparative subjective scale also shown in Table 1. By using the two forms of subjective scale it was hoped to obtain a more accurate measure of the difference between the systems.

For all the tests, the viewing distance was between five and six times the picture height; the white brightness of the display was 20 ft-L (215 a.s.b.) and the average unexcited brightness of the cathode-ray tube screen was approximately 1 ft-L (10·8 a.s.b.).

4. RESULTS OF SUBJECTIVE TESTS

Tables 2 to 5, inclusive, summarise the results obtained by averaging the opinions which the observers recorded for each test condition. In addition to the mean grade corresponding to each test condition, the 'standard error'* of the mean has also been computed. The standard error gives a convenient estimate of the error due to the employment of a finite number of observers and enables the significance of the difference in the means of two sets of absolute gradings to be assessed. If two sets of observations have means of x_1 and x_2 and standard errors of S_1 and S_2 respectively, the difference $x_1 - x_2$ is taken to be insignificant if $|x_1 - x_2| < 3S$, where S is the greater of the standard errors. In the case of the comparative grades, however, a mean grade is taken to be insignificant if it is less than twice the standard error.

4.1. Reception of 'Narrow-Band 625'

The assessments using the picture-quality scale shown in Table 1 resulted in the mean subjective gradings shown in Table 2 below.

TABLE 2

	ABSOLUTE SUBJECTIVE GRADES (A)			
	NON-TECHNICAL OBSERVERS		TECHNICAL OBSERVERS	
	MEAN GRADE	STANDARD ERROR	MEAN GRADE	STANDARD ERROR
'Normal 405'	2·47	0·1	2·87	0·18
'Normal 625'	2·32	0·1	3·03	0·18
'Narrow-Band 625'	2·26	0·11	3·98	0·18

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* The standard error of the mean of a group of N observations with a standard deviation σ is defined as $\sigma/\sqrt{N}$.

From the results in Table 2, it will be seen that the non-technical observers recorded assessments which did not differ significantly for the three systems. The technical observers, however, recorded no significant difference between 'normal 405' and 'normal 625', but their results show that 'Narrow-Band 625' is about one subjective grade worse than the other two.

The comparative assessments, using the comparative scale shown in Table 1, resulted in the mean subjective gradings shown in Table 3 below.

TABLE 3

SYSTEM COMPARED WITH 'NARROW-BAND 625'	COMPARATIVE SUBJECTIVE GRADES (C)			
	NON-TECHNICAL OBSERVERS		TECHNICAL OBSERVERS	
	MEAN GRADE*	STANDARD ERROR	MEAN GRADE*	STANDARD ERROR
'Normal 405'	-0•42	0•11	+1•97	0•31
'Normal 625'	-0•42	0•11	+1•1	0•25

* A positive sign denotes that the system considered is better than 'Narrow-Band 625' and a negative sign worse than 'Narrow-Band 625'.

These results show that the non-technical observers actually preferred the 'Narrow-Band 625' system to the other two normal systems; this is difficult to understand, slight though the preference may be. The technical observers showed a much greater preference for the normal systems.

In a short supplementary test, a comparison was made between the effects of positive and negative modulation of the vision carrier. It was found that, using any of the six slides, it was not easy and sometimes not possible to decide which polarity of modulation was in use. From this it was concluded that either polarity of modulation was equally acceptable.

4.2. Reception of 'Pulse-Sound 625'

The assessments using the picture-quality scale shown in Table 1 resulted in the mean subjective gradings shown in Table 4 below.

TABLE 4

	ABSOLUTE SUBJECTIVE GRADES (A)			
	NON-TECHNICAL OBSERVERS		TECHNICAL OBSERVERS	
	MEAN GRADE	STANDARD ERROR	MEAN GRADE	STANDARD ERROR
'Normal 405'	2•70	0•09	2•33	0•21
'Normal 625'	2•54	0•1	2•93	0•18
'Pulse-Sound 625'	2•57	0•1	2•95	0•18

In this case, both the non-technical and technical observers recorded assessments which did not differ significantly for the three systems.

The comparative assessments using the comparative scale shown in Table 1 resulted in the mean subjective gradings shown in Table 5 below.

TABLE 5

SYSTEM COMPARED WITH 'PULSE-SOUND 625'	COMPARATIVE SUBJECTIVE GRADES (C)			
	NON-TECHNICAL OBSERVERS		TECHNICAL OBSERVERS	
	MEAN GRADE*	STANDARD ERROR	MEAN GRADE*	STANDARD ERROR
'Normal 405'	+0•02	0•11	+1•34	0•27
'Normal 625'	+0•04	0•11	−0•02	0•22

* A positive sign denotes that the system considered is better than 'Pulse-Sound 625' and a negative sign worse than 'Pulse-Sound 625'.

It will be seen that, only in the case of 'normal 405', was any significant difference found.

4.3. Discussion of Results

In general, the results show that the non-technical observers found little difference between the reception of normal 405-line and 625-line transmissions and the reception of 625-line transmissions of reduced bandwidth resulting from the 'Narrow-Band 625' and 'Pulse-Sound 625' proposals. On the other hand, the technical observers found the 'Narrow-Band 625' transmissions significantly inferior to the normal 405-line and 625-line transmissions and also inferior to the 'Pulse-Sound 625' transmissions. It seems reasonable to regard the technical observers as representative of the most critical section of the viewing public and on this basis 'Narrow-Band 625' and the variation outlined in Section 1 could not be regarded as acceptable.

The results showed some preference by the technical observers for normal 405 transmissions as opposed to normal 625 transmissions; however, the preference, where statistically significant, was small.

5. CONCLUSIONS

Subjective tests are described which were made in order to assess two proposals whereby 625-line transmissions could be accommodated in radio-frequency channels of 5 Mc/s bandwidth. The results show that the picture quality resulting from both the proposals would be acceptable to the average non-technical viewer. However, assessments made by technical observers indicate that, although the picture quality associated with the proposal known as 'Pulse-Sound 625' would be acceptable to the discriminating viewer, the picture quality associated with the proposal known as 'Narrow-Band 625' would not.

6. REFERENCES

1. Technical Data used by the European V.H.F./U.H.F. Broadcasting Conference, Stockholm, 1961, Fig. 23.

2. ibid, Fig. 17.

3. ibid, Fig. 29 (assuming 4·43 Mc/s subcarrier frequency).

4. ibid, page 37.

APPENDIX

The Transmission of 625-Line Television Signals in a 5 Mc/s Channel, using Pulse-Sound

In this Appendix, the video-frequency bandwidth and the bandwidth of the vestigial sideband of the 'Pulse-Sound 625' system are considered. It is assumed that it would ultimately be required to radiate colour transmissions and that a colour subcarrier of approximately 3·6 Mc/s would be appropriate. In the following sub-sections, the interference from transmissions in the lower and upper adjacent channels is discussed with reference to Fig. 1.

1. Attenuation of the Vestigial Sideband of a Colour Television Signal at the Transmitter

The vestigial sideband of the unwanted signal transmitted in the lower adjacent channel would contain an image of its colour subcarrier which would give rise to a beat of 1·4 Mc/s with the wanted vision carrier and the protection ratio required[1] would be 43 dB. Assuming equal field strengths of the wanted and unwanted vision signals, this figure can be reduced by 20 dB by allowing, on the one hand, for aerial directivity[2] (6 dB) and, on the other hand, for the relative maximum subcarrier level (14 dB) so that the attenuation of the image colour-subcarrier required at the transmitter is 23 dB.

2. Receiver Response at the Frequency of the Colour Subcarrier of the Upper Adjacent Channel

The colour subcarrier of the upper adjacent channel would give rise to a beat of 1·4 Mc/s with the wanted vision carrier and the protection ratio required[1] would be 37 dB. This figure can be reduced by 20 dB for the reasons given in Section 1 above and the required maximum receiver response relative to that at the vision carrier frequency will therefore be -17 dB.

3. Receiver Response at the Frequency of the Vision Carrier of the Lower Adjacent Channel

This would cause a beat pattern of 5 Mc/s in the case of monochrome-signal reception and 1·4 Mc/s in the case of colour-signal reception. Taking the colour case as being the more severe, the protection ratio required[3] would be about 35 dB. With equal field strengths of wanted and unwanted signals and allowing 6 dB for aerial directivity, the required maximum receiver response would be approximately -29 dB.

4. Response/Frequency Characteristic of the Receiver

The protection ratios quoted in (1), (2) and (3) above are applicable to adjacent channel interference occurring for a small percentage of the time.[4] However, it is possible that in some cases interference may be continuous and as a result, the protection ratio would need to be some 10 to 20 dB higher.[4] Further, in the case of (3) above, the interference is assumed to be due to the vision carrier frequency of the lower adjacent channel and it is possible that interference from the sidebands will need to be taken into account. Laboratory tests, however, will need to be carried out to determine precisely the protection ratios that can be achieved with pulse-sound. If interference is present for only a small percentage of the time, a nominal video frequency bandwidth of 4•5 Mc/s and a vestigial sideband bandwidth of 1 Mc/s would seem possible. If interference is continuous, it would probably be necessary to reduce these bandwidths slightly but even in this case the video frequency bandwidth of the practical receiver shown dotted in Fig. 3(*c*) should be satisfactory. It is therefore felt that the results given in this report can be considered typical of those which would be realised in a practical pulse-sound system.

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